TECHNICAL PUBLICATION

COMPUTER PROGRAM
FOR GEODETIC
DISTANCE PROBLEMS

WARNING

This document contains information affecting the national defense of the United States, within the meaning of Title 18, sections 793 and 794, of the U.S. Code, as amended. Its transmission or revelation of its contents to or receipt by an unauthorized person is prohibited by law.

RECORD COPY			COPY NO.		PUB. DATE		LOCATION			MASTER		DATE RECEIVED			LOCATION		
										STOCK LEVEL		MINIMUM /			MAXIMUM /		
DISPOSITION DATE(S)										COPIES DESTROYED							
CUT TO COPIES		DATE		CUT TO COPIES		DATE											
CUT TO COPIES		DATE		CUT TO COPIES		DATE											
CUT TO COPIES		DATE		MASTER		DATE								NUMBER OF COPIES			
DATE			RECEIVED OR ISSUED			NUMBER OF COPIES			DATE			RECEIVED OR ISSUED			REC'D	ISS'D	BAL
MO.	DAY	YR.				REC'D	ISS'D	BAL	MO.	DAY	YR.						
12	11	68	Dist. Unit			1		1									
10	16	72	Dest 1 Copy					0	W	K	G						

TITLE

NPIC/R-5016/66   June 1966   SEC. CLASS.   LOCATION

S   505100

DATE			RECEIVED OR ISSUED	NUMBER OF COPIES			DATE			RECEIVED OR ISSUED	NUMBER OF COPIE		
MO.	DAY	YR.		REC'D	ISS'D	BAL	MO.	DAY	YR.		REC'D	ISS'D	BAL

TITLE

SEC. CLASS.   LOCATION

TABLE OF CONTENTS

COMPUTER PROGRAM FOR
GEODETIC DISTANCE PROBLEMS

INTRODUCTION

The Groundhog Program is designed to solve 2 types of geodetic distance problems, the direct and the inverse, when the distance is greater than 500 statute miles.

DIRECT PROBLEM

In the direct problem, the latitude and longitude of Point A and the distance from A to Point B is input with the azimuth of AB. The program computes and prints the latitude and longitude of Point B and the back azimuth BA (See illustration 2).
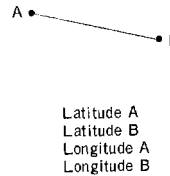


```
        INPUT                OUTPUT
    NORTH                        NORTH

      ∝                         β
   A      d                  A
              B                      B

 Distance (d)          Back azimuth BA = 360°- β
 Azimuth AB (∝)        Latitude B
 Latitude A            Longitude B
 Longitude A
```



```
          NORTH
                        NORTH
           ∝        β
        A              B

 0° ≤ Azimuth ≤ 360° (measured clockwise from true north)
 Azimuth AB = ∝
 Back azimuth BA = 360°- β
```
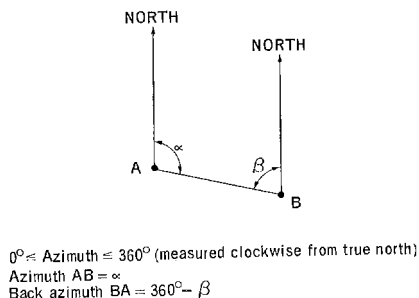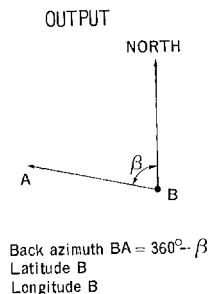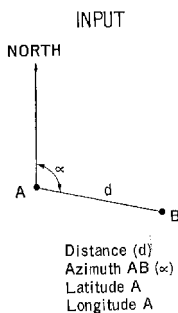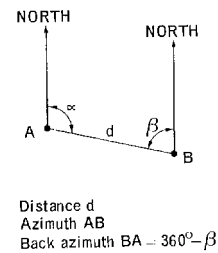
INVERSE PROBLEM

In the inverse problem, the latitude and longitude of 2 points, A and B, are input and the program computes and prints the distance between the points and the azimuths of AB and BA.


```
     INPUT               OUTPUT

                      NORTH
                            NORTH
  A                    ∝
        B           A    d    β
                            B

 Latitude A          Distance d
 Latitude B          Azimuth AB
 Longitude A         Back azimuth BA = 360°-β
 Longitude B
```

RESTRICTIONS

On the inverse problem, the desired units for output must be such that no more than 8 digits are used for distance output. This situation will arise only when distance output is in feet. If more than 8 digits are needed for distance output, an error will occur and "Distance In Feet Exceeds Program" is printed out.

INPUT FORMAT

Conventions

1. Latitude values will be between $0°$ and $90°$. An "N" following a latitude value indicates north latitude; an "S" indicates south latitude.

2. Longitude values will be between $0°$ and $180°$. "E" indicates east longitude; and "W" indicates west longitude.

3. Zero° north latitude is considered equivalent to $0°$ south latitude. Zero° east longitude is considered equivalent to $0°$ west longitude.

Options

1. Units code

Distances may be input and output in feet, meters, statute miles, or nautical miles at

- 1 -

the discretion of the user. The code for the different units is as follows:

1 - feet
2 - meters
3 - statute miles
4 - nautical miles

Choice of units is indicated by code number on the input card.

2. System code

The user has the option of using the AMS, Bessel, Clarke 1866, or International Ellipsoids in the computer program. Choice is indicated by the appropriate code letter on the input card. The system code is as follows:

A - AMS
B - Bessel
C - Clarke 1866
D - International Ellipsoids

Card Formats

Table 1. Card Format for Direct Problem

Columns	No of Columns Used	Description	Example
1-11	11	Latitude of point A*	034-15-00.0
12	1	Blank	
13	1	N or S*	N
14-17	4	Blank	
18-28	11	Longitude of point A*	115-00-00.0
29	1	Blank	
30	1	E or W*	W
31-34	4	Blank	
35-45	11	Azimuth of AB**	081-25-25.0
46-50	5	Blank	
51-58	8	Distance from A to B***	01710562
59	1	Blank	
60	1	Units code number (1,2,3, or 4)	3
61-64	4	Blank	
65	1	System code letter (A,B,C, or D)	A
66-69	4	Blank	
70-80	11	Notes	

*Latitude and longitude are expressed in degrees, minutes, and tenths of seconds, with dashes punched in columns 4, 7, 21, and 24, separating degrees from minutes and minutes from seconds. A decimal point is punched in columns 10 and 27. Column 13 will always have either an N or an S to in-

dicate whether the latitude is north or south. Column 30 will always have either an E or a W to indicate whether the longitude is east or west. Since latitude is always between ± 90°, column 1 will always be 0°.
**Azimuth is expressed in degrees, minutes, and tenths of seconds. A dash is punched in column 38 between degrees and minutes and in column 41 between minutes and seconds. A decimal point is punched in column 44.
***Distance may be expressed in feet, meters, nautical miles, or statute miles. When distance is given in either nautical miles or statute miles, the program will accept the data in thousandths of a unit. Therefore, when the units code number is 3 or 4, there is an assumed decimal point between card columns 55 and 56. When input is in feet or meters, the data in columns 50-58 are assumed to be integers.

Table 2. Card Format for Inverse Problem

Columns	No of Columns Used	Description	Example
1-11	11	Latitude of point A*	034-15-00.0
12	1	Blank	
13	1	N or S*	N
14-17	4	Blank	
18-28	11	Longitude of point A*	115-00-00.0
29	1	Blank	
30	1	E or W*	W
31-34	4	Blank	
35-45	11	Latitude of point B*	035-15-00.0
46	1	Blank	
47	1	N or S*	N
48-51	4	Blank	
52-62	11	Longitude of point B*	085-16-12.4
63	1	Blank	
64	1	E or W*	W
65	1	Blank	
66	1	Units code number (1,2,3, or 4)	3
67	1	Blank	
68	1	System code letter (A,B,C, or D)	A
69	1	Blank	
70-80	11	Notes	

*Latitude and longitude are expressed in degrees, minutes, and tenths of seconds. Dashes are punched in columns 4, 7, 21, 24, 38, 41, 55 and 58, separating degrees from minutes and minutes from seconds. Columns 10, 27, 44, and 61 will always contain decimal points. Either an N or S is punched in columns 13 and 47 to indicate whether the latitude is north or south. Either an E or a W is punched in columns 30 and 64 to indicate whether the longitude is east or west. Since latitude is between ± 90°, columns 1 and 35 will always be punched with a 0.

- 2 -

<table>
<tr><td align="center" colspan="4">Table 3. Sentinel Card</td></tr>
<tr><td>Columns</td><td>No of Columns Used</td><td>Description</td><td>Example</td></tr>
<tr><td>1-5
6-80</td><td>5
75</td><td>5 Slashes
Notes</td><td>/////</td></tr>
</table>

Deck Arrangement

The program will accommodate any number of input cards in any sequence. Both the direct problem and the inverse problem may be submitted in the same deck. The last card in any deck must be a sentinel card.

OUTPUT

Error Detection

A check for magnitude is made on each card to be sure that the latitude is between ±90°, longitude between ±180°, azimuth between 0° and 360°, and distance less than the circumference of the earth. If an error has been made in punching a data card, the message, "Format Error in Column   ," is printed and the card is not processed. The program uses card column 47 to determine whether the card contains the direct or inverse problem. Therefore, if column 47 is incorrectly punched, the program will not interpret the type of problem correctly. This will produce an error when column 51 or 55 is checked and the message, "Format Error in Column 51" or "Format Error in Column 55," will be printed.

Accuracy

The Groundhog Program solves the direct problem to within one second of arc in azimuth and latitude, with a maximum error in longitude of one second of arc for every 3.8 million meters. The inverse problem is solved to within one second of arc in azimuth and 1:100,000 for distance.

─────── • ───────

SECRET

SECRET